

## CLAIMS

What we claim is:

1. A micro-positioner, comprising:  
5 a mounting assembly for accepting and holding a media or component;  
a shuttle assembly, the shuttle assembly being attached to the mounting assembly; and  
the shuttle assembly being adapted to move directionally in response to control signals.
2. The micro-positioner of Claim 1, further comprising the shuttle assembly being  
adapted to move in a single direction.
- 10 3. The micro-positioner of Claim 1, further comprising the shuttle assembly being  
adapted to move in an X-direction and Y-direction.
4. The micro-positioner of Claim 1, the mounting assembly adapted for holding an  
optical fiber.
5. The micro-positioner of Claim 1, the mounting assembly adapted for holding a lens.
- 15 6. The micro-positioner of Claim 1, further comprising being adapted to position a  
media or component with a tolerance in the nanometer range and travel in the micron range.
7. The micro-positioner of Claim 1, being adapted to hold, release and reposition a  
media or component a plurality of times over the life of the micro-positioner.
8. The micro-positioner of Claim 1, further comprising:  
20 an electronic circuit responsively coupled to the shuttle assembly; and  
the shuttle assembly being adapted to move in response to electronic signals from the  
electronic circuit.
9. The micro-positioner of Claim 8, further comprising:

a substrate having a top surface, a substantially planar bottom surface, and an aperture substantially centered through the bottom surface to the top surface;

the shuttle assembly further comprising a set of expansion bars springs and clamps for each direction of movement;

5 the set of expansion bars, springs and clamps being positioned and retained on the top surface of the substrate;

the expansion bars being manufactured of an expansion material adapted to expand and retract upon the application of a current directed by the electronic circuit;

10 the set of springs being positioned between a rigid surface of the substrate and a side of each of the expansion bars, the springs being operable to apply a force to the side of the expansion bars;

the springs being further operable to provide a flexible electrical interconnect, and a stabilization member for out-of-plane motion;

the clamps being manufactured of an expansion material adapted to expand and retract upon the application of a current directed by the electronic circuit;

15 the clamps being positioned to hold the expansion bars in place when the clamps are in a contracted state, when no electrical power is applied;

the clamps being operable to release the expansion bars when the clamps are in an expanded state, when electrical power is applied;

the mounting assembly being rigidly attached to the expansion bars; and

20 the mounting assembly being centered over the substrate aperture when the shuttle is in a neutral location.

10. The micro-positioner of Claim 9, being adapted to move in a single direction such as X, Y, or Z.

11. The micro-positioner of Claim 9, further comprising being adapted to move in two dimensions such as X-direction and Y-direction.

12. The micro-positioner of Claim 9, wherein the mounting assembly is further adapted for holding an optical fiber.

5 13. The micro-positioner of Claim 9, wherein the mounting assembly is further adapted for holding a lens.

14. The micro-positioner of Claim 9, further comprising:

the electronic circuit operable to drive current through the expansion bars and clamps in a predetermined sequence and level;

10 the expansion bars and clamps being adapted to heat and cool and thereby expand and retract, in response to the pre-determined sequence and level; and

the expansion bars and mounting assembly being movable in response to the application of a sequence of current through the expansion bars and clamps.

15 15. The micro-positioner of Claim 8, further comprising the shuttle assembly having four directional subassemblies: a left X-direction subassembly, a right X-direction subassembly, an up Y-direction subassembly, and a down Y-direction subassembly; and

each directional subassembly comprising an interoperable set of clamps, springs and expansion bars.

20 16. The micro-positioner of Claim 15, further comprising being operable to move in a specific direction by the application of a sequence of electronic signals to one or more specific directional subassemblies.

17. The micro-positioner of Claim 15, further comprising being manufactured on a semiconductor substrate.

18. The micro-positioner of Claim 15, further comprising bonding pads being positioned on the substrate and responsively coupling the electronic circuit to the micro-positioner.

19. The micro-positioner of Claim 1, further comprising:

one or a plurality of pinion actuators;

5 one or a plurality of pinion drives;

one or a plurality of pinion releases;

one or a plurality of axis hold actuators;

x-axis and y-axis slides;

a movable aperture with slides;

10 the movable aperture and slides being guided by the x-axis and y-axis slides;

the pinions being adapted to be at rest or in motion;

at rest, all pinion actuators being in contact with and clamping the movable aperture such that the movable aperture is locked into position;

in motion, a set of holding actuators being operable to expand and release the movable  
15 aperture when a voltage is applied thereto;

a set of pinion drive actuators operable to expand and push the movable aperture in the desired position when an additional voltage is applied thereto;

the set of holding actuators being operable to contract and clamp the movable aperture after voltage is removed from the set of holding actuators;

20 the pinion release actuator being adapted to expand and release the movable aperture when a voltage is applied thereto;

the pinion drive and the pinion being adapted to move back to its rest position when a voltage is removed therefrom; and

the pinion release and the pinion being adapted to contract back to clamp the movable aperture when a voltage is removed therefrom.

20. The micro-positioner of Claim 19, further comprising bond pads adapted to receive voltage pulses to step the micro-positioner.

5 21. The micro-positioner of Claim 19, further comprising being adapted to move in the X-direction by operation and timing of the stepping procedure on the X-axis actuators.

22. The micro-positioner of Claim 19, further comprising being adapted to move in the y-direction by operation and timing of the stepping procedure on the Y-axis actuators.

10 23. The micro-positioner of Claim 19, further comprising being fabricated using chemical etching procedures.

24. The micro-positioner of Claim 19, further comprising:  
an expansion mechanism adapted to move the movable aperture;  
the expansion mechanism comprised of two wide arms adapted for low electrical resistance;  
the expansion mechanism further comprised of two narrow for much greater electrical  
15 resistance; and

all four arms being electrically connected such that when voltage is applied at the corresponding bond pads, current flows through all four arms.

25. The micro-positioner of Claim 24, further comprising the expansion mechanism adapted to physically contract when a voltage is applied, thus moving the slides to place the  
20 actuators into contact with movable aperture; and

the removal of voltage from the slides operable to cause the slides to contract and move to a rest position.

26. The micro-positioner of Claim 19, further comprising being manufactured as a silicon chip.

27. The micro-positioner of Claim 19, further comprising being implemented in one or a plurality of dimensions.

5 28. An apparatus for positioning a media or component, comprising:  
a semiconductor substrate with a top surface and a bottom surface;  
a shuttle assembly being flexibly mounted on the top surface of the substrate;  
the shuttle assembly comprising a set of clamps, expansion material, and a movable mount;  
the clamps and expansion material being adapted to expand and contract with the application  
10 of a control signal;

the expansion material being held rigid by the clamps when the clamps are contracted, when no electrical power is applied;

the expansion material being released by the clamps when the clamps are expanded;

the expansion material being adapted to expand and move upon release by the clamps and  
15 when the expansion material expands, when electrical power is applied;

the expansion material being adapted to be locked into position by the clamps when the clamps contract;

29. The apparatus for positioning a media or component of Claim 28, further comprising:

the expansion material and clamps being adapted to expand upon the heating thereof; and

20 the expansion material and clamps being adapted to contract upon the cooling thereof.

30. The apparatus for positioning a media or component of Claim 29, further comprising the expansion material and clamps being heated upon the application of a voltage thereto; and the expansion material and clamps being cooled upon the reduction of voltage thereto.

31. The apparatus for positioning a media or component of Claim 28, further comprising the shuttle assembly being adapted to move in a single direction, X-direction, Y-direction, or Z direction.

32. The apparatus for positioning a media or component of Claim 28, further comprising the shuttle assembly being adapted to move in two dimensions, X-direction and Y-direction.

33. The apparatus for positioning a media or component of Claim 28, further comprising a mounting assembly attached to the center of the shuttle assembly, adapted for accepting and holding an optical fiber.

34. The apparatus for positioning a media or component of Claim 28, further comprising a mounting assembly attached to the center of the shuttle assembly, adapted for accepting and holding a lens.

35. The apparatus for positioning a media or component of Claim 28, further comprising being adapted to position a media or component within a tolerance in the nanometer range and travel in the micron range.

36. The apparatus for positioning a media or component of Claim 28, further comprising being adapted to hold, release and reposition a media or component a plurality of times over the life of the apparatus.

37. The apparatus for positioning a media or component of Claim 28, further comprising:  
a movable mount being attached proximate the center of the expansion material when the apparatus is in a neutral state;

the clamps being coupled to the expansion material proximate the ends of the expansion material when the apparatus is in a neutral state;

the movable mount being operable to accept a media or component;

an expansion material being operable to expand and retract and thus move and control the position of the movable mount;

the clamps being operable to expand and contract and thus control the direction of the expansion material expansion and contraction and thus movement of the expansion material and the  
5 movable mount;

the clamps being operable to hold the movable mount into position after movement without applied voltage or current;

a circuit being coupled to the clamps and expansion material; and

the circuit being operable to generate electronic signals to dynamically control the expansion  
10 and contraction of the clamps and the expansion material.

38. The apparatus for positioning a media or component of claim 37, wherein the expansion material is silicon.

39. The apparatus for positioning a media or component of claim 37, wherein the control signal further comprises voltages applied to the clamps and expansion material in a predetermined  
15 sequence.

40. The apparatus for positioning a media or component of Claim 37, wherein the movable mount has an aperture adapted to receive an optical fiber.

41. The apparatus for positioning a media or component of Claim 37, wherein the apparatus is operable to align the media or component to within nanometers and has a range of travel  
20 in microns.

42. The apparatus for positioning a media or component of Claim 37, wherein the apparatus is operable to hold, release, and reposition the media or component over multiple cycles.

43. A device for aligning a media or component comprising:

a micro-positioner situated on a substrate;

a mount positioned on the micro-positioner, the mount being adapted to accept a media or component; and

the micro-positioner operable to position the media or component within a tolerance in the  
5 nanometer range and travel in the micron range.

44. The apparatus for positioning a media or component of Claim 43, wherein the apparatus is operable to hold, release, and reposition the media or component over multiple cycles.

45. The apparatus for positioning a media or component of Claim 44, further comprising a collimating lens apositioned proximate the micro-positioner; and

10 the micro-positioner being operable to align the mount and hence an optical fiber with the collimating lens along one or a plurality of axes.

46. The apparatus for positioning a media or component of Claim 44, the micro-positioner being operable to align the mount and hence optical fiber with the collimating lens along two axes.

15 47. The apparatus for positioning a media or component of Claim 44, wherein the mount comprises an array of apertures;

the apertures being adapted to receive a plurality of optical fibers; and

the micro-positioner being operable to control the positions of the array of optical fibers.

48. The apparatus for positioning a media or component of Claim 44, further comprising  
20 a collimating lens apositioned proximate the micro-positioner; and

the micro-positioner being operable to align the array of optical fibers with the collimating lenses along one or a plurality of axes.

49. The apparatus for positioning a media or component of Claim 48, the micro-positioner being operable to align the array of optical fibers with the collimating lenses along two axes.

50. The apparatus for positioning a media or component of Claim 43, wherein the micro-positioner comprises a set of expansion bars and a set of clamps;

the set of expansion bars and set of clamps being mechanically coupled;

the set of expansion bars being responsively coupled to a circuit with a potential;

the set of clamps being responsively coupled to a circuit with a potential;

the potential causing a current to flow through the circuit including the expansion bars and clamps;

the current flow through the circuit operable to cause an expansion or retraction of the set of expansion bars and set of clamps; and

the expansion or retraction of the set of expansion bars and set of clamps being operable to cause the mount to move along a desired axis.

51. The apparatus for positioning a media or component of Claim 50, wherein the mount comprises an aperture adapted to receive an optical fiber.

52. The apparatus for positioning a media or component of Claim 51, wherein the polarity, amplitude and duration of the potential applied to the set of expansion bars and set of clamps controls the speed and direction of the motion of the mount.

53. The apparatus for positioning a media or component of Claim 52, wherein the micro-positioner is operable to dynamically align the aperture for accepting the unbuffered optical fiber side in step sizes from a few nanometers to a few micrometers.

54. An optical fiber package, comprising:

a substantially cylindrical jacket with a predetermined cross-sectional radius with a first end and a second end;

a cylindrical lens with a first surface and a second surface with a predetermined cross-sectional radius about the same radius as the jacket;

5 the lens having a cross-section appropriate for secure mounting within the second end of the jacket;

a micro-positioner having a front surface and a back surface and an aperture for accepting the unbuffered optical fiber through the front surface and back surface;

10 the micro-positioner being positioned perpendicularly to the walls of the jacket within the jacket;

the micro-positioner being firmly attached to the jacket;

a fiber guide being inserted and securely mounted within the first end of the jacket to a predetermined length of the jacket, the predetermined length being less than the length between the first end of the jacket and the front surface of the micro-positioner;

15 the fiber guide having a lengthwise bore centered with the cylindrical jacket so as to form channel for accepting one end of a buffered optical fiber;

the bore in the guide being graduated in diameter so as to accept a buffered optical fiber at the first end of the jacket to a smaller diameter at the terminating end of the bore so as to accept the unbuffered optical fiber emanating from the buffered optical fiber and inserted into the micro-positioner.

20 a free space void being formed between the terminating end of the fiber guide and the front surface of the micro-positioner;

the unbuffered optical fiber being inserted in the first end of the fiber guide within the jacket to a predetermined length of the jacket, the predetermined length being less than the length between the first end of the jacket and the first end of the lens;

5 a free space void being formed between the terminating surface of the unbuffered optical fiber and the first surface of the lens;

a set of control leads being responsively coupled to the micro-positioner for electrically controlling the micro-positioner;

the set of control leads being routed out of the jacket; and

the micro-positioner being operable to dynamically position the unbuffered optical fiber.

10 55. The optical fiber package of Claim 54, wherein the lens, micro-positioner, and guide are attached with adhesives, plastics, solder, braze, or weld.

56. The optical fiber package of Claim 54, wherein the micro-positioner is adapted to adjust the optical fiber along an axis to within a tolerance in the nanometer range and travel in the micron range.

15 57. The optical fiber package of Claim 54, wherein the micro-positioner is adapted to adjust the optical fiber along a plurality of axes.

58. The optical fiber package of Claim 57, wherein the micro-positioner further comprises:

a first expansion bar for controlling motion along an X-axis;

20 a second expansion bar for controlling motion along a Y-axis;

a plurality of X direction clamps for holding and releasing the first expansion bar;

a plurality of Y direction clamps for holding and releasing the second expansion bar; and a circuit responsively coupled to the to the first expansion bar, second expansion bar, X direction

clamps and Y direction clamps operable to dynamically align the aperture for accepting the unbuffered optical fiber.

59. The optical fiber package of Claim 58, wherein the first expansion bar and the second expansion bar have predetermined thermal expansion characteristics.

5 60. The optical fiber package of Claim 58, wherein the micro-positioner is operable to dynamically align the aperture for accepting the unbuffered optical fiber side in step sizes from nanometers to micrometers.

61. The optical fiber package of Claim 58, wherein the direction and step size of motion of the aperture for accepting the unbuffered optical fiber is controlled by the voltage or current  
10 applied to the first expansion bar, second expansion bar, X-direction clamps and Y direction clamps.

62. The optical fiber package of Claim 61, further comprising the micro-positioner being operable to dynamically align the aperture for accepting the unbuffered optical fiber; and the micro-positioner being adapted to lock into position after manipulation.

63. The optical fiber package of Claim 61, wherein the micro-positioner operable to  
15 dynamically align the aperture for accepting the unbuffered optical fiber can be readjusted after manipulation.

64. The optical fiber package of Claim 62, wherein the package has the form factor of a collimator or connector.

65. An apparatus for aligning fiber, comprising:  
20 a plurality of micro-positioners, the micro-positioners comprising a set of horizontal and vertical arms that expand and contract;

a plurality of clamps, one or more clamps being positioned on each end of each micro-positioner arm;

each clamp being operable to hold or release the micro-positioner arm to which it correlates;  
an aligner, said aligner comprising a mount with an aperture for a fiber, the aperture being adapted for receiving and holding a fiber threaded through the aperture;

the aligner being secured to the micro-positioner arms between the clamps;

5 the micro-positioners having a control mechanism for expanding or retracting the micro-positioner arms; and

a control circuit for holding or releasing the clamps and expanding or retracting the micro-positioner arms so as to move the aligner into a desired location.

66. The apparatus for aligning fiber of Claim 65, further comprising being adapted to  
10 move optical components into a desired location.

67. The apparatus for aligning fiber of Claim 65, further comprising being self-locking such that when power is not supplied, the components remain anchored.

68. The apparatus for aligning fiber of Claim 65, further comprising a single channel dynamic collimator.

15 69. The apparatus for aligning fiber of Claim 68, further comprising:  
a fiber guide that is adapted to align bare fiber into the micro-positioner;  
the micro-positioner being adapted to move the fiber with precision in two dimensions; and  
the micro-positioner being adapted to lock the fiber or component position in place after movement.

20 70. The apparatus for aligning fiber of Claim 69, further comprising a buffered fiber, fiber and collimator or connector jacket; and

the buffered fiber, fiber and fiber guide being securely fastened either mechanically or with epoxy, solder, braze, or weld into the collimator jacket.

71. The apparatus for aligning fiber of Claim 70, further comprising

a collimating lens; and

electrical leads, being passed through the collimator jacket, the electrical leads being adapted to control the collimating lens.

5 72. The apparatus for aligning fiber of Claim 71, further comprising the micro-positioner being adapted to adjust the collimating lens with precision in two dimensions.

73. An apparatus for aligning fiber, comprising:

a plurality of collimators or connectors arranged in an array;

a fiber guide adapted to receive and align bare fibers of a buffered fiber, an end of which has

10 been stripped to expose a plurality of fibers;

an NxM micro-positioner;

the NxM micro-positioner being adapted to move the fibers individually with precision in two dimensions; and

the NxM micro-positioner being adapted to lock the fibers individually in place after

15 movement.

74. The apparatus for aligning fiber of Claim 73, further comprising:

a collimator jacket;

a buffered fiber;

a plurality of exposed fibers emanating from an end of the buffered fibers or ribbon;

20 the buffered fibers, exposed fibers and the fiber guide being securely fastened into the collimator jacket;

a collimating lens array panel;

electrical control leads, said electrical control leads being passed through the collimator jacket; and said electrical control leads being responsively coupled to the micro-positioner.

75. The apparatus for aligning fiber of Claim 74, wherein the buffered fiber, exposed fibers and the fiber guide being securely fastened into the collimator jacket mechanically, soldered,  
5 brazed, welded, or with epoxy.

76. The apparatus for aligning fiber of Claim 75, being adapted to permit alignment of the fiber in the field.

77. The apparatus for aligning fiber of Claim 75, wherein said components are within a self-contained housing.

10 78. An apparatus for aligning a media, comprising:  
a micro-positioner;  
the micro-positioner having an aligner;  
the aligner being adapted to receive a media;  
a control circuit;  
15 the control circuit being responsively coupled to the micro-positioner and aligner via control leads; and

the location of aligner being adjustable by applying electrical signals or pulses comprising current through, or a voltage across, micro-positioner arms in certain control sequences to define the direction and distance of the motion of the aligner in one or two dimensions.

20 79. The apparatus for aligning a media of Claim 78, wherein the media comprises a fiber.

80. The apparatus for aligning a media of Claim 78, wherein the fiber comprises optical fiber.

81. The apparatus for aligning a media of Claim 78, wherein the amplitude or duration of the electrical signals, or pulses, defines the distance traveled by the aligner.

82. The apparatus for aligning a media of Claim 78, wherein the micro-positioner is locked in position to ensure anchoring at the desired location when no voltage or current is applied.

5 83. The apparatus for aligning a media of Claim 78, wherein the micro-positioner is constructed using semiconductor technology.

84. The apparatus for aligning a media of Claim 78, wherein the micro-positioner is further comprised of a plurality expansion bars having thermal expansion characteristics; and

the expansion bars of the micro-positioner being adapted to receive control signals; and the  
10 application of control signals causing movement of the micro-positioner, and hence, adjustment of the media.

85. The apparatus for aligning a media of Claim 84, wherein each expanding, or contracting, expansion bar(s), has a set of corresponding clamps on the ends thereof; and the hold and release operation of the clamps being operable to create a precision stepping motion.

15 86. The apparatus for aligning a media of Claim 85, wherein the micro-positioner is implemented using microelectromechanical systems (MEMS) technology.

87. The apparatus for aligning a media of Claim 85, wherein the micro-positioner is implemented using discrete mechanical elements for clamps or expansion bars or springs.

88. The apparatus for aligning a media of Claim 78, wherein the micro-positioner further  
20 comprises a set of expansion bars; and

the set of expansion bars operable cause motion of a mount comprising silicon etched gears and/or racks.

89. The apparatus for aligning a media of Claim 78, wherein the media comprises a nozzle.

90. The apparatus for aligning a media of Claim 78, wherein the media comprises a valve.

5 91. The apparatus for aligning a media of Claim 78, wherein the media comprises an antenna element.

92. The apparatus for aligning a media of Claim 78, further comprising being operable as an active, adaptive antenna array.

93. The apparatus for aligning a media of Claim 78, wherein the control signals  
10 positioning the micro-positioner are responsive to a predetermined RF profile.

94. A method for positioning a media, comprising:  
threading and securing a fiber through a mount attached to a micro-positioning shuttle;  
applying a voltage to a clamp within the micro-positioning shuttle causing the clamp to heat  
and expand;

15 applying a voltage to an expansion bar within the shuttle causing the expansion bar to heat  
and expand;

reducing the voltage to the clamp once the fiber is at a desired location, causing the clamp to  
cool and contract and thus lock the expansion bar in place; and

reducing the voltage to the expansion bar, causing the expansion bar to cool.

20 95. The method for positioning a media of Claim 94, wherein the media comprises a fiber.

96. The method for positioning a media of Claim 95, wherein the fiber comprises an optical fiber.

97. The method for positioning a media of Claim 94, wherein the media comprises a conductive fiber or wire.

98. The method for positioning a media of Claim 94, wherein the media comprises a hollow tube.

5 99. The method for positioning a media of Claim 94, wherein the media is aligned to a tolerance in the nanometer range.

100. The method for positioning a media of Claim 94, wherein the clamp and expansion bar components of the micro-positioning shuttle can be heated, expanded cooled and reposition multiple times over the life of the micro-positioning shuttle.

10 101. A method for positioning a component, comprising:

securing a component to a mount attached to a micro-positioning shuttle;  
applying a voltage to a clamp within the micro-positioning shuttle causing the clamp to heat, expand, and to release one end of the expansion bar;

15 applying a voltage to an expansion bar within the shuttle causing the expansion bar to heat and expand;

reducing the voltage to the clamp once the component is at a desired location, causing the clamp to cool and contract and thus lock the expansion bar in place; applying a voltage to a second clamp on the other end of the expansion bar to cause it to release, and reducing the voltage to the expansion bar, causing the expansion bar to cool, and reducing the voltage on the second clamp to  
20 cause it to lock the other end of the expansion bar.

102. The method for positioning a component of Claim 101, wherein the component comprises a lens, prism, or other optical component.

103. The method for positioning a component of Claim 101, wherein the component comprises a electrical element such as a laser diode or detector.

104. The method for positioning a media of Claim 101, wherein the component is aligned to a tolerance in the nanometer range.

5        105. The method for positioning a component of Claim 101, wherein the clamp and expansion bar components of the micro-positioning shuttle can be heated, expanded cooled and reposition multiple times over the life of the micro-positioning shuttle.